

D-A101 175

NEW JERSEY DEPT OF ENVIRONMENTAL PROTECTION TRENTON F/O 13/13
NATIONAL DAM SAFETY PROGRAM. WATCHUNG LAKE DAM (NJ00767), RARIT--ETC(U)
JUL 81 J P TALERICO DACW61-79-C-0011

UNCLASSIFIED

DAEN/NAP-53842/NJ00767-81/ NL

101
40
A1011-5

END
DATE
FILMED
7-81
DTIC

LEVEL 11

1

AD A101125

RARITAN RIVER BASIN
STONY BROOK, SOMERSET COUNTY
NEW JERSEY

WATCHUNG LAKE DAM

NJ 00767

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
DAEW61-79-C-0011



APPROVED FOR PUBLIC RELEASE
DISTRIBUTION UNLIMITED.

DEPARTMENT OF THE ARMY

Philadelphia District
Corps of Engineers
Philadelphia, Pennsylvania

REPT. NO. DAEN/NAP-53842/NJ00767-8/07

JULY 1981

"Original contains color
plates: All DTIC reproductions
will be in black and
white"

DTIC FILE COPY

81 7 09 001

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER DAEN/NAP-53842/NJ00767-81/07	2. GOVT ACCESSION NO. AD-A101175	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Phase I Inspection Report National Dam Safety Program Watchung Lake Dam, NJ00767 Somerset County, NJ		5. TYPE OF REPORT & PERIOD COVERED FINAL
7. AUTHOR(s) Talerico, John P.		6. PERFORMING ORG. REPORT NUMBER 15
9. PERFORMING ORGANIZATION NAME AND ADDRESS Harris-ECI Associates 453 Amboy Ave. Woodbridge, N.J. 07095		8. CONTRACT OR GRANT NUMBER(s) DACW61-79-C-0011
11. CONTROLLING OFFICE NAME AND ADDRESS NJ Department of Environmental Protection Division of Water Resources P.O. Box CN029 Trenton, NJ 08625		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) U.S. Army Engineer District, Philadelphia Custom House, 2d & Chestnut Streets Philadelphia, PA 19106		12. REPORT DATE July 1981
		13. NUMBER OF PAGES 65
		15. SECURITY CLASS. (of this report) Unclassified
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES Copies are obtainable from National Technical Information Service, Springfield, Virginia 22151.		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Dams National Dam Safety Program Erosion Embankments Watchung Lake Dam, N.J. Visual Inspection Seepage Structural Analysis Spillways		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.		

NOTICE

THIS DOCUMENT HAS BEEN REPRODUCED
FROM THE BEST COPY FURNISHED BY
THE SPONSORING AGENCY. ALTHOUGH
IT IS RECOGNIZED THAT CERTAIN POR-
TIONS ARE ILLEGIBLE, IT IS BEING
RELEASED IN THE INTEREST OF MAKING
AVAILABLE AS MUCH INFORMATION AS
POSSIBLE.



IN REPLY REFER TO
NAPEN-N

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE-2 D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

23 JUN 1981

Honorable Brendan T. Byrne
Governor of New Jersey
Trenton, New Jersey 08621

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Watchung Lake Dam in Somerset County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given in the front of the report.

Based on visual inspection, available records, calculations and past operational performance, Watchung Lake Dam, a high hazard potential structure, is judged to be in good overall condition. The dam's spillway is considered inadequate because a flow equivalent to 49 percent of the Spillway Design Flood - SDF - would cause the dam to be overtopped. (The SDF, in this instance, is one half of the Probable Maximum Flood). The decision to consider the spillway "inadequate" instead of "seriously inadequate" is based on the determination that dam failure resulting from overtopping would not significantly increase the hazard to loss of life downstream from the dam from that which would exist just before overtopping failure. To ensure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures and studies within six months from the date of approval of this report. Within three months of the consultant's findings remedial measures to ensure spillway adequacy should be initiated.

b. Within twelve months from the date of approval of this report, the following remedial actions should be completed:

(1) The flow of seepage should be monitored frequently to determine its volume and whether it presents a problem to the safety of the dam.

APPROVED FOR PUBLIC RELEASE
DISTRIBUTION UNLIMITED.

NAPEN-N

Honorable Brendan T. Byrne

(2) All brush and trees should be removed from the embankment crest and slopes to avoid problems which may develop from roots. Also fill in cavities with suitable material. The embankment face should then be seeded to develop a growth of grass for surface erosion protection.

(3) Repair all spalled and cracked concrete on the spillway, low-level outlet channel and concrete retaining wall.

(4) Remove up-rooted trees from the downstream channel.

(5) Fill in eroded areas on the banks of the downstream channel with suitable material and place slope protection to prevent future erosion.

(6) Determine if the low-level outlet valve is operable, and if not, make repairs as necessary.

(7) Conduct a complete topographic survey of the dam and surrounding area, in order to develop a detailed plan and several cross-sections of the dam to form a coherent as-built set.

c. The owner should develop an emergency action plan outlining actions to be taken by the operator to minimize downstream effects of an emergency and establish a flood warning system for the downstream communities within three months from the date of approval of this report.

d. The owner should develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam within one year from the date of approval of this report.

A copy of the report is being furnished to Mr. Dirk C. Hofman, New Jersey Department of Environmental Protection, the designated State Office contact for this program. Within five days of the date of this letter, a copy will also be sent to Congresswoman Fenwick of the Fifth District. Under the provision of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, five days after the date of this letter.

Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

APPROVED	✓
DATE	
BY	
DISTRIBUTION	
AVAILABILITY	
ACQUISITION	
POST	
A	

NAPEN-N

Honorable Brendan T. Byrne

An important aspect of the Dam Inspection Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely,



JAMES G. TON
Colonel, Corps of Engineers
Commander and District Engineer

1 Incl
As stated

Copies furnished:

Mr. Dirk C. Hofman, P.E., Deputy Director
Division of Water Resources
N.J. Dept. of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

Mr. John O'Dowd, Acting Chief
Bureau of Flood Plain Regulation
Division of Water Resources
N.J. Dept. of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

WATCHUNG LAKE DAM (NJ00767)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 8 January and 25 February 1981 by Harris-ECI Associates, under contract to the State of New Jersey. The State, under agreement with the U.S. Army Engineer District, Philadelphia, had this inspection performed in accordance with the National Dam Inspection Act, Public Law 92-367.

Watchung Lake Dam, a high hazard potential structure, is judged to be in good overall condition. The dam's spillway is considered inadequate because a flow equivalent to 49 percent of the Spillway Design Flood - SDF - would cause the dam to be overtopped. (The SDF, in this instance, is one half of the Probable Maximum Flood). The decision to consider the spillway "inadequate" instead of "seriously inadequate" is based on the determination that dam failure resulting from overtopping would not significantly increase the hazard to loss of life downstream from the dam from that which would exist just before overtopping failure. To ensure adequacy of the structure, the following actions, as a minimum, are recommended:

a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures and studies within six months from the date of approval of this report. Within three months of the consultant's findings remedial measures to ensure spillway adequacy should be initiated.

b. Within twelve months from the date of approval of this report, the following remedial actions should be completed:

(1) The flow of seepage should be monitored frequently to determine its volume and whether it presents a problem to the safety of the dam.

(2) All brush and trees should be removed from the embankment crest and slopes to avoid problems which may develop from roots. Also fill in cavities with suitable material. The embankment face should then be seeded to develop a growth of grass for surface erosion protection.

(3) Repair all spalled and cracked concrete on the spillway, low-level outlet channel and concrete retaining wall.

(4) Remove up-rooted trees from the downstream channel.

(5) Fill in eroded areas on the banks of the downstream channel with suitable material and place slope protection to prevent future erosion.

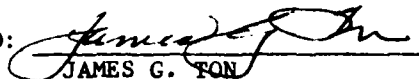
(6) Determine if the low-level outlet valve is operable, and if not, make repairs as necessary.

(7) Conduct a complete topographic survey of the dam and surrounding area, in order to develop a detailed plan and several cross-sections of the dam to form a coherent as-built set.

c. The owner should develop an emergency action plan outlining actions to be taken by the operator to minimize downstream effects of an emergency and establish a flood warning system for the downstream communities with three months from the date of approval of this report.

d. The owner should develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam within one year from the date of approval of this report.

APPROVED:



JAMES G. TON

Colonel, Corps of Engineers
Commander and District Engineer

DATE:

22 June 1981

RARITAN RIVER BASIN
STONY BROOK, SOMERSET COUNTY
NEW JERSEY

WATCHUNG LAKE DAM

NJ00767

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
PHILADELPHIA, PENNSYLVANIA 19106

JULY, 1981

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Name: Watchung Lake Dam, I.D., NJ 00767
State Located: New Jersey
County Located: Somerset County
Stream: Stony Brook
River Basin: Raritan River Basin
Date of Inspection: January 8 and February 25, 1981

Assessment of General Conditions

Watchung Lake Dam is an earthfill dam with an overflow concrete spillway at the left end of the dam. The overall condition of the dam is good. There are no major signs of distress or instability in the embankment. Minor seepage was observed at three locations in the downstream face of the main spillway and at one location in the auxiliary spillway. The concrete facing along the crest and downstream slope of the spillway is cracked and spalled. The downstream channel is well defined but has erosion along both banks. The hazard potential is rated as "high".

Watchung Lake Dam is considered inadequate in view of its lack of spillway capacity to pass the SDF (1/2 PMF) without overtopping the dam. The spillway is capable of passing a flood equal to 24.0 percent of the PMF, (48.0 percent of the 1/2 PMF), and is assessed as "inadequate".

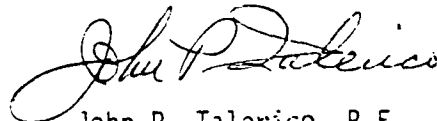
At present, the engineering data available is not sufficient to make a definitive statement on the stability of the dam, but based on the findings of the visual inspection, the preliminary assessment of static stability is that it is satisfactory. The following actions are recommended along with a timetable for their completion. All recommended actions should be conducted under the supervision of an Engineer who is experienced in the design, construction and inspection of dams.

1. Carry out a more precise hydrologic and hydraulic analysis of the dam within twelve months, to determine the need and type of mitigating measures necessary. Based on the results of these studies, remedial measures should be instituted. This should include the installation of a tailwater gage.
2. The flow of seepage should be monitored frequently to determine its volume and whether it presents a problem to the safety of the dam.

3. All brush and trees should be removed from the embankment crest and slopes to avoid problems which may develop from roots. Also fill in cavities with suitable material. The embankment face should then be seeded to develop a growth of grass for surface erosion protection. This program should be started within twelve months.
4. Repair all spalled and cracked concrete on the spillway, low-level outlet channel and concrete retaining wall. This work should be completed within twelve months.
5. Remove uprooted trees from downstream channel within twelve months.
6. Fill in eroded areas on banks of downstream channel with suitable material and place slope protection to prevent future erosion. This should be started within twelve months.
7. Determine if the low-level outlet valve is operable, and if not, make repairs as necessary. This should be done within twelve months.
8. The owner should develop an emergency action plan (if one is not already available) outlining actions to be taken by the operator to minimize downstream effects of an emergency and establish a flood warning system for the downstream communities within three months.

Furthermore, while of a less urgent nature, the following additional actions are recommended and should be carried out within one year.

1. The owner should develop, within one (1) year after formal approval of the report, written operating procedures and a periodic maintenance plan to insure the safety of the dam.
2. Conduct a complete topographic survey of the dam and surrounding area in order to develop a detailed plan and several cross-sections of the dam to form a coherent as-built set.



John P. Talerico, P.E.
HARRIS-ECI ASSOCIATES



Photo taken February 25, 1981

WATCHUNG LAKE DAM

View of dam looking towards right end.

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the office of the Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The test flood provides a measure of relative spillway capacity and serves as an aide in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

TABLE OF CONTENTS

ASSESSMENT OF GENERAL CONDITIONS

OVERVIEW PHOTO

PREFACE

Page

SECTION 1	PROJECT INFORMATION	1
	1.1 General	1
	1.2 Description of Project	1
	1.3 Pertinent Data	5
SECTION 2	ENGINEERING DATA.....	7
	2.1 Design	7
	2.2 Construction.....	7
	2.3 Operation	7
	2.4 Evaluation.....	7
SECTION 3	VISUAL INSPECTION.....	8
	3.1 Findings	8
SECTION 4	OPERATION PROCEDURES.....	10
	4.1 Procedures	10
	4.2 Maintenance of Dam.....	10
	4.3 Maintenance of Operating Facilities.....	10
	4.4 Evaluation	10
SECTION 5	HYDRAULIC/HYDROLOGIC	11
	5.1 Evaluation of Features.....	11
SECTION 6	STRUCTURAL STABILITY	13
	6.1 Evaluation of Structural Stability.....	13
SECTION 7	ASSESSMENT/REMEDIAL MEASURES	15
	7.1 Dam Assessment	15
	7.2 Remedial Measures	15

TABLE OF CONTENTS CONTINUED

<u>PLATES</u>	<u>No.</u>
KEY MAP.....	1
VICINITY MAP.....	2
GEOLOGIC MAP.....	3
DRAWINGS OF DAM.....	4

APPENDICES

APPENDIX A - CHECK LIST - VISUAL OBSERVATIONS CHECK LIST - ENGINEERING, CONSTRUCTION, MAINTENANCE DATA	1 - 11
APPENDIX B - PHOTOGRAPHS	
APPENDIX C - SUMMARY OF ENGINEERING DATA	1
APPENDIX D - HYDROLOGIC COMPUTATIONS	1 - 19

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

WATCHUNG LAKE DAM, I.D. NJ 00767

S E C T I O N 1

1. PROJECT INFORMATION

1.1 General

a. Authority

The National Dam Inspection Act (Public Law 92-367, 1972) provides for the National Inventory and Inspection Program by the U.S. Army Corps of Engineers. This inspection was made in accordance with this authority under Contract C-FPM No. 35 with the State of New Jersey who, in turn, is contracted to the Philadelphia District of the Corps of Engineers, and was carried out by the engineering firm of Harris-ECI Associates of Woodbridge, New Jersey.

b. Purpose of Inspection

The visual inspection of Watchung Lake Dam was made on January 8 and February 25, 1981. The purpose of the inspection was to make a general assessment as to the structural integrity and operational adequacy of the dam embankment and its appurtenant structures.

c. Scope of Report

The report summarizes available pertinent data relating to the project; presents a summary of visual observations made during the field inspection; presents an evaluation of hydrologic and hydraulic conditions at the site; presents an evaluation as to the structural adequacy of the various project features; and assesses the general condition of the dam with respect to safety.

1.2 Description of Project

a. Description of Dam and Appurtenances

Watchung Lake Dam is an earthfill dam approximately 420 feet long and 19.2 feet high with a rubble core wall. There is a 223 foot concrete spillway at the left end of the dam. The first 84.5 feet of the spillway, which is at the left end of the dam, is only overflowed during high water levels,

and has a 5-inch curb running along the upstream face of its crest. There is a beach area that has been added on the upstream side of this section. The remaining 138.5 feet, which is the main spillway, is an overflow section with a 24 foot notched section on the left side. The top of the curb along the auxiliary spillway is about 1.9 feet below the top of the embankment with the crest of the main spillway 1.15 feet lower than the curb of the auxiliary spillway. In the notch of the main spillway there are nine concrete blocks each approximately 0.45 feet high and 1 foot wide. Along the downstream crest is a 3 foot high railing that, with the blocks, is used to aid people in crossing the spillway on their way to the beach. At the right end of the spillway is a 2.3 foot wide concrete abutment wall. It extends from the edge of the lake along the right side of the spillway and continues about 25 feet beyond the bottom of the spillway. From there it angles left away from the dam for 79 feet, then turns right for 25 feet and ends. Most of the area between the wall and the bottom of the spillway has been concreted except for the central portion which is comprised of broken concrete barriers, stone rubble and a growth of trees and brush. Along the left end of the dam is a concrete abutment wall which extends upstream as a barrier between the roadway and beach.

The embankment has a minimum top width of 20 feet at the left end and increases to 71 feet at the right end, and according to the records has a 24-inch thick rubble core wall.

The low-level outlet consists of a 30-inch reinforced concrete pipe located in the right abutment approximately 20 feet downstream of the bottom of the spillway. The flow, which is controlled by a manually operated valve located in the downstream embankment slope, discharges onto a concrete channel that parallels the spillway.

The overflow from the spillway runs down across the apron and discharges into Stony Brook approximately 95 feet downstream from the dam. The flow continues eastward passing under Valley Road through a 6.5 foot by 26 foot opening approximately 350 feet downstream from the dam. From there the channel continues northeast for another 350 feet before it turns southeast crossing under Watchung Avenue (Route 531) approximately 1,000 feet downstream of the spillway. There are two buildings along the channel before it crosses Watchung Avenue and eight, including the municipal offices, just downstream, all within the flood plain.

A generalized description of the soil conditions is contained in Report No. 7, Somerset County, Engineering Soil Survey of New Jersey, by Rutgers University. The report, dated 1953, describes the soil as silt and silty clay with frequent gravelly phases reflecting the presence of large quantities of partially disintegrated basalt. The underlying formation is Newark Basalt which is a dense hard homogenous-appearing rock lying from 0 to 10 feet below the surface. On Geologic Overlay Sheet 25, Watchung Lake Dam lies on the boundary between a Brunswick Formation (shale) and a Basalt Flow.

b. Location

Watchung Lake Dam is located on Stony Brook in the Township of Watchung, Somerset County, New Jersey. It is accessible from U.S. Route 22 at North Plainfield by way of Watchung Avenue (Route 531) to Stirling Road on its north or Mountain Boulevard on its south.

c. Size Classification

According to the "Recommended Guidelines for Safety Inspection of Dams" by the U.S. Department of the Army, Office of the Chief of Engineers, the dam is classified in the dam size category as being "small", since its storage volume of 149 acre-feet is less than 1,000 acre-feet. The dam is also classified as small because its height of 19.2 feet is less than 40 feet. The overall size classification of Watchung Lake Dam is small.

d. Hazard Classification

A hazard potential classification of "high" has been assigned to the dam on the basis that a hypothetical failure would result in excessive damage to the heavily traveled Valley Road and Watchung Avenue (Route 531), to the many residential and commercial buildings along the channel and to the parking area immediately downstream of the dam for those using the lake. The possibility therefore exists of the loss of more than a few lives in the event of dam failure.

e. Ownership

Watchung Lake Dam is owned by:

Mr. John H. McDonough
307 Long Hill Drive
Short Hills, NJ 07078
(201) 376-5224

f. Purpose

Watchung Lake Dam is presently used to impound water for recreational purposes.

g. Design and Construction History

Watchung Lake Dam was rebuilt in 1912 for the purpose of harvesting ice. At that time a plan was presented to add an additional spillway along the left shore line, but it was never built. In 1945 the left side of the dam was overtopped. In October 1973, the dam was inspected by the Bureau of Water Control to determine the effects of the August 1973 flooding, and with only minor repairs necessary, was found to be in satisfactory condition. In March of 1974, old concrete barriers were placed along the toe of the earth embankment for added stability and broken concrete slabs were placed in the downstream discharge channel. An inspection by the Bureau of Water Control, in June 1947, revealed that the spillway has been raised 4 to 6 inches as a result of repairs. Also the left portion of the downstream side was filled with gravel, asphalt, concrete slabs, and left-over concrete. No further information was available on repairs to the dam or the removal of the rubble.

h. Normal Operating Procedures

The discharge from the lake is unregulated and allowed to naturally balance the inflow into the lake. The low-level outlet is used to periodically lower the lake level to allow for cleaning of the beach area and any necessary repairs.

1.3 Pertinent Data

a. Drainage Area 3.49 sq. mi.

b. Discharge at Dam Site

Ungated spillway capacity at elevation of top of dam: 3,133 cfs (203.2 NGVD)

Total spillway capacity at maximum pool elevation (SDF): 6,218 cfs (204.36 NGVD)

c. Elevation (Feet above NGVD)

Top of dam: (Embankment) 203.2

Maximum pool design surcharge (SDF): 204.36

Recreation pool: 200.15

Spillway crest: Main: 200.15
Auxiliary: 201.3

Streambed at centerline of dam: 184.0

Maximum tailwater: 185.0

d. Reservoir

Length of maximum pool: 1,800 (Estimated)

Length of recreation pool: 1,400 (Estimated)

e. Storage (acre-feet)

Spillway Crest: 93

Top of dam: 149

Maximum pool (SDF): 175

f. Reservoir Surface (acres)

Top of dam: 23 (Estimated)

Maximum pool (SDF): 29 (Estimated)

Recreation pool: 16 (Estimated)

Spillway crest: 16 (Estimated)

g. Dam

Type:	Earthfill with concrete spillway and rubble core wall.
Length:	420 ft. (Effective)
Height:	19.2 ft.
Top width:	Varies - 20 ft. to 71. ft.
Side slopes - Upstream:	2H:1V
- Downstream:	2H:1V
Zoning:	Unknown
Impervious core:	Rubble core wall
Cutoff:	Unknown
Grout curtain:	None

h. Diversion and Regulating Tunnel

N/A

i. Spillway

Type:	Broad crest notched concrete weir
Length of weir:	Main: 138.5 ft. Auxiliary: 84.5 ft.
Crest elevation:	Main: 200.15 Auxiliary: 201.3
Gates:	None
U/S Channel:	Watchung Lake
D/S Channel:	Stony Brook

j. Regulating Outlets

Low level outlet:	30-inch R.C.P.
Controls:	Manually operated
Emergency gate:	None
Outlet:	184.33 NGVD

SECTION 2

2. ENGINEERING DATA

2.1 Design

A drawing showing the earth embankment in 1912 is available at the Trenton offices of NJ Department of Environmental Protection (NJ-DEP). No data from soil borings, soil tests, or other geotechnical data is available. Data concerning the hydraulic capacity of the spillway is also unavailable.

2.2 Construction

Data is not available concerning the as-built construction of the dam. No data exists on the construction methods, borrow sources, or other data pertinent to the construction of the dam.

2.3 Operation

Formal operation records are not kept for the dam and reservoir. The lake is allowed to operate naturally without regulation.

2.4 Evaluation

a. Availability

The availability of engineering data is poor. The stated drawing and some correspondence concerning the spillway modification are available from the NJ-DEP.

b. Adequacy

The engineering data available, together with that obtained in the field, was adequate to perform hydrologic and hydraulic computations. The data was insufficient to perform a stability analysis, but preliminary evaluation could be made based on visual observations.

c. Validity

Information contained in the drawing, permit application and checked by limited field measurement appears to be valid.

SECTION 3

3. VISUAL INSPECTION

3.1 Findings

a. General

The visual inspection of Watchung Lake Dam revealed the dam, including the spillway, to be in good condition, but in the need of repairs. At the time of inspection, the water level was at the crest of the main spillway.

b. Dam

The earth embankment appears to be sound. The horizontal alignment of the upstream and downstream edges of the crest is very irregular, and the vertical alignment appears good. There are some trees and brush growing on the upstream slope. Numerous trees and brush are growing along the crest of the downstream slope and along the slope. Some of the trees on the downstream slope have been uprooted leaving cavities. There was no surface cracking observed along the embankment or at and beyond the toe of the slope. The toe of the downstream slope has been reinforced with a double layer of old concrete barrier curbs. The area adjacent to the downstream toe serves as a parking lot for those using the lake. No evidence of burrowing by animals was observed; however, at the time of the inspection there was a heavy growth of brush covering the embankment, therefore the possibility does exist that there may be burrow holes in the embankment.

c. Appurtenance Structures

1. Spillway

The concrete spillway comprises approximately the left half of the dam. It consists of three sections. The first extends 98 feet from the left abutment and is 8.5 feet wide. The first 4 feet from the downstream crest is level then slopes upward for 4.5 feet with a 5-inch concrete curb extending from the left end 84.5 feet to the right along the upstream crest. In addition there is also a chain link fence along the upstream crest the entire 98 feet. The upstream crest is approximately 1 foot above the downstream crest. There is a beach area behind part of this section of the spillway. The second section is a 24 feet long notch with its crest 0.3 feet lower than the rest of the spillway. There are 9 concrete block across the top of this section and a 3 foot high railing along the downstream crest. The blocks and railing are there to provide access across the spillway for those using the lake. The remaining 101 feet is a 4.6 foot wide broad crested section ending at the right abutment wall. Leakage was noticed on the downstream face 10 feet and 35 feet to the left of the right abutment approximately one-third of the way down from the crest. There was also seepage observed 20 feet to the left of the abutment wall and 35 feet to the left

of the notch at the toe. The concrete facing along the top and downstream face of the main spillway is cracked and spalled. Along the top of the notch, the concrete blocks used to provide access to the beach were cracked, deteriorated and two of them were missing. A good deal of patch work was observed along the top and downstream face of the entire spillway.

2. Outlets

The low-level outlet is a 30-inch reinforced concrete pipe running through the earth embankment. The inlet was underwater and could not be observed at the time of inspection. The pipe discharges parallel to the spillway onto a concrete channel. The flow through the pipe is controlled through the use of a wheel operated valve located in the downstream slope. At the time of inspection the valve was leaking slightly as there was water running out of the pipe. The operation of the valve was not demonstrated as the wheel was not available.

d. Reservoir

The side slopes of the reservoir area are moderately flat with homes along the shoreline. There is a swimming area along the left shore immediately upstream from the dam. There were no signs of slope instability and the lake appeared clean with no signs of surface growth.

e. Downstream Channel

The discharge channel from the spillway has a rough concrete bottom. There is an area below the main spillway which is cluttered with broken concrete barriers, stone rubble and has some trees growing in it. Below the left side of the spillway old concrete and asphalt has been dumped for slope protection. Heavy spalling was observed in the outlet pipe discharge channel and along the face of the concrete retaining wall which runs perpendicular to the dam and parallel to the discharge channel. The flow over the spillway and from the outlet pipe runs toward the right side of the spillway discharge channel. At a point approximately 95 feet from the dam the spillway discharge channel ends with a 1 foot drop into the natural channel of Stony Brook. The side slopes are 5 to 6 feet high and almost vertical. The banks are severely eroded causing the uprooting of some trees on the left side. Some concrete rubble has been placed on the right bank just downstream of the end of the discharge apron. The channel then crosses under Valley Road approximately 350 feet downstream from the dam. From there the channel continues northeast for another 350 feet before it turns southeast and crosses under Watchung Avenue (Route 531) approximately 1,000 feet downstream of the spillway. There are two buildings along the channel between Valley Road and Watchung Avenue and eight, including the miniciple building, just downstream of Watchung Avenue. All the buildings are within the flood plain.

SECTION 4

4. OPERATIONAL PROCEDURES

4.1 Procedures

Watchung Lake Dam is used to impound water for recreational activities. The level of the lake is maintained through the unregulated flow over the spillway and the lake is lowered periodically to allow for cleaning and maintenance of the beach area.

4.2 Maintenance of the Dam

There is no regular inspection and maintenance program for the dam and appurtenant structures. Mr. John H. McDonough, the owner, is responsible for the maintenance of the dam.

4.3 Maintenance of Operating Facilities

The low-level outlet operating facilities consists of the one manually operated 30-inch gate valve. At the time of inspection, operation of the valve was not demonstrated and it was leaking slightly as there was water running out of the pipe.

4.4 Evaluation

The present operational and maintenance procedures are fair with the dam and spillway being maintained in a serviceable condition.

SECTION 5

5. HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design

The drainage area above Watchung Lake Dam is approximately 3.49 square miles. A drainage map of the watershed of the dam site is presented on Plate 1, Appendix D.

The topography within the basin is generally moderately sloped. Elevations range from approximately 540 feet above NGVD at the northwest end of the watershed to about 200 feet at the dam site. Land use patterns within the watershed are mostly woodland with some residential development.

The evaluation of the hydraulic and hydrologic features of the dam was based on criteria set forth in the Corps guidelines and additional guidance provided by the Philadelphia District, Corps of Engineers. The SDF for the Dam falls in a range of 1/2 PMF to PMF. In this case, the low end of the range, 1/2 PMF, is chosen since the factors used to select size and hazard classification are on the low-side of their respective ranges.

The Probable Maximum Flood (PMF) was calculated from the Probable Maximum Precipitation using Hydrometeorological Report No. 33 with standard reduction factors. Due to the small drainage area, the SCS triangular hydrograph transformed to a curvilinear hydrograph was adopted for developing the unit hydrograph, with the aid of the HEC-1- DB Flood Hydrograph Computer Program.

Initial and constant infiltration loss rates were applied to the Probable Maximum Precipitation to obtain rainfall excesses. The rainfall excesses were applied to the unit hydrograph to obtain the PMF and various ratios of PMF utilizing program HEC-1-DB.

The SDF peak outflow calculated for the dam is 6,218 cfs. This value is derived from the half PMF, and results in overtopping the dam, assuming that the lake was originally at the spillway crest elevation.

The stage-outflow relation for the spillway was determined from the geometry of the spillway and dam, utilizing HEC-1- Dam Safety version program.

The reservoir stage-storage capacity relationship was computed directly by the conic method, utilizing the HEC-1-DB program. The reservoir surface areas at various elevations were measured by planimeter from a U.S.G.S. Quadrangle topographic map. Reservoir storage capacity included surcharge levels exceeding the top of the dam, the spillway rating curve was based

on the assumption that the dam remains intact during routing. The spillway rating curve is presented in the Hydrologic Computation, Appendix D.

A breach analysis indicates that the stage of the stream 1,000 feet downstream, where it crosses Watchung Avenue, is 0.6 feet higher due to dam failure from overtopping at 0.3 PMF than it would be without failure at 0.3 PMF. This is likely not to jeopardize the well traveled road downstream more than without failure. The discharge facility is thus rated "inadequate".

Drawdown calculations indicate that to empty the lake to an elevation of 185.0 NGVD through the one low-level outlet would take 16.3 hours, assuming a 2 cfs/square mile inflow. This is considered to be an adequate drawdown period, and provision of additional outlets are not necessary.

b. Experience Data

No records of reservoir stage or spillway discharges are maintained for this site.

c. Visual Observation

The downstream channel is well defined and in good condition. The banks are steep with trees growing on the slopes and top. The channel crosses under Valley Road, 350 feet downstream of the spillway and then Watchung Avenue 1,000 feet downstream of the spillway. Many residential and commercial buildings are immediately downstream of the dam.

The side slopes of the reservoir are flat to moderate with homes along the shoreline and no signs of instability. The drainage area is primarily wooded with some development.

d. Overtopping Potential

A storm of magnitude equivalent to the SDF would cause overtopping of the dam to a height of 1.16 feet. Computations indicate that the dam can pass approximately 24.0 percent of the PMF without overtopping the dam crest. Since the 1/2 PMF is the Spillway Design Flood (SDF) for this dam, according to the Recommended Guidelines for Safety Inspection of Dams by the Corps of Engineers, the spillway capacity of the dam is assessed as "inadequate".

SECTION 6

6. STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

There are no major signs of distress in the embankment of Watchung Lake Dam. There are trees growing along the crest at the downstream slope and on both slopes, which could pose a threat to stability. The spillway has some cracking and spalling along the top and downstream face. There was seepage observed in several locations along the spillway's downstream face. The locations of the seepage are: 10 and 35 feet to the left of the right abutment approximately one-third of the way down the face, 20 feet left of the abutment and 35 feet to the left of the notch at the toe. The seepage has not been monitored and no information was uncovered concerning their duration or flow rates.

b. Design and Construction Data

No design computations relating to stability were uncovered during the report preparation phase. No embankment or foundation soil parameters are available for carrying out a conventional stability analysis on the embankment. No construction data or specifications relating to the degree of embankment compaction are available for use in the stability analysis.

c. Operating Records

No operating records are available relating to the stability of the dam. The dam and spillway have served satisfactorily since its reconstruction in 1912.

d. Post-Construction Changes

Watchung Lake Dam was rebuilt in 1912. There are no records showing any changes until 1974. In the beginning of that year a double layer of concrete barrier curb was placed along the toe of the embankment for additional stability. Pieces of this barrier curb were also put in the discharge channel at this time. An inspection by the Bureau of Water Control in June of 1974 stated that the addition of a beach has shortened the spillway and the addition of concrete for repairs has raised the crest elevation from 4 to 6 inches. The dates of these modifications are not known.

e. Static Stability

A static stability analysis was not performed on the Watchung Lake Dam because the lack of data on which to base assumptions of material properties inside embankment zones might produce misleading results, but based on the findings of the visual inspection, the preliminary assessment of static stability is that it is satisfactory.

f. Seismic Stability

The dam is located in Seismic Zone 1, as defined in the Recommended Guidelines for Safety Inspection of Dams, prepared by the Corps of Engineers. In general, projects located in Seismic Zones 0, 1 and 2 may be assumed to present no hazard from earthquake, provided the static stability conditions are satisfactory and conventional safety margins exist, and based on the findings of the visual inspection, the preliminary assessment of the static and seismic stabilities is that they are satisfactory.

SECTION 7

7. ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

a. Safety

The dam has been inspected visually and a review has been made of the available engineering data. This assessment is subject to the limitations inherent in the visual inspection procedures stipulated by the Corps of Engineers for a Phase I report.

Watchung Lake Dam is inadequate because the dam does not have the spillway capacity to pass the SDF, one half of the PMF, without overtopping. Overtopping of the dam carries with it the danger of a possible failure of the dam. The present spillway capacity of the dam is approximately 24.0 percent of the PMF.

No definitive statement pertaining to the safety of the embankment can be made without acquisition of embankment material engineering properties, but based on the findings of the visual inspection, preliminary assessment of the static stability is that it is satisfactory.

b. Adequacy of Information

The information uncovered was adequate to perform hydrologic and hydraulic computations. The data was insufficient to perform even an approximate computation of the stability of the dam. A preliminary assessment of the dam could be made by visual observation only.

c. Urgency

The remedial measures and recommended actions along with a timetable for their completion are detailed below. All recommended action should be conducted under the supervision of an engineer who is experienced in the design, construction and inspection of dams.

7.2 Remedial Measures

a. Alternatives for Increasing Spillway Capacity

Alternatives for increasing spillway capacity are as follows:

1. Increase the embankment height of the dam thus permitting a higher discharge to pass.

2. Lower the spillway crest elevation.
3. Increase the effective spillway crest length.
4. A combination of any of the above alternatives.

b. Recommendations

1. Carry out a more precise hydrologic and hydraulic analysis of the dam within twelve months, to determine the need and type of mitigating measures necessary. If required, conduct a study of the means of increasing spillway discharge capacity and develop alternative schemes for construction. This should include the installation of headwater and tailwater gages. The ability of the dam to withstand overtopping should also be studied.
2. The flow of seepage should be monitored frequently to determine its volume and whether it presents a problem to the safety of the dam.
3. All brush and trees should be removed from the embankment crest and slopes to avoid problems which may develop from roots. Also fill in cavities with suitable material. The embankment face should then be seeded to develop a growth of grass for surface erosion protection. This program should be started within twelve months.
4. Repair all spalled and cracked concrete on the spillway, low-level outlet channel and concrete retaining wall. This work should be completed within twelve months.
5. Remove up rooted trees from downstream channel within twelve months.
6. Fill in eroded areas on banks of downstream channel with suitable material and place slope protection to prevent future erosion. This should be started within twelve months.
7. Determine if the low-level outlet valve is operable, and if not, make repairs as necessary. This should be done within twelve months.

The following additional actions are recommended:

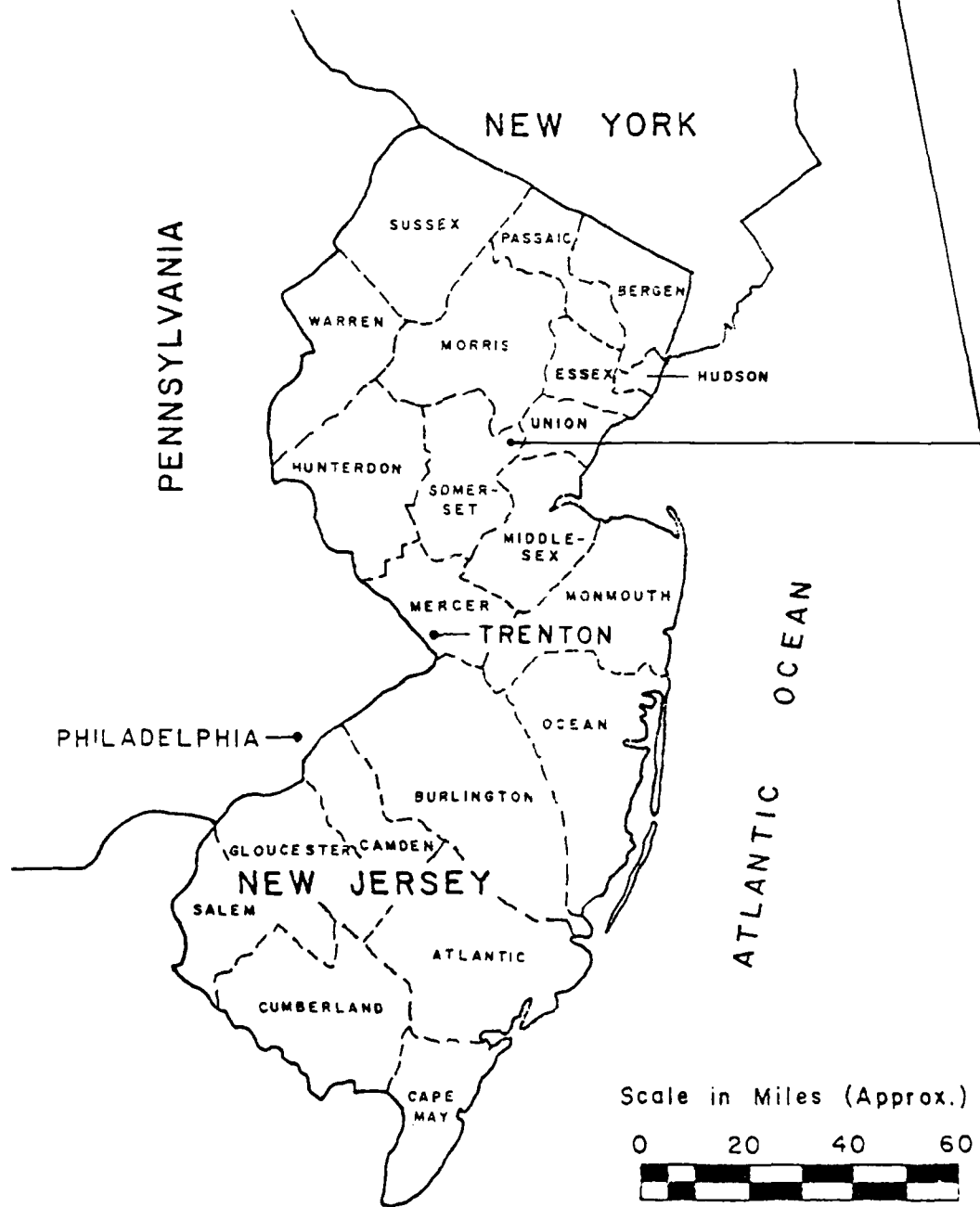
1. The owner should develop an emergency action plan (if one is not already available) outlining actions to be taken by the operator to minimize downstream effects of an emergency and establish a flood warning system for the downstream communities within three months.
2. Conduct a complete topographic survey of the dam and surrounding area, in order to develop a detailed plan and several cross-sections of the dam to form a coherent as-built set.

c. O & M Procedures

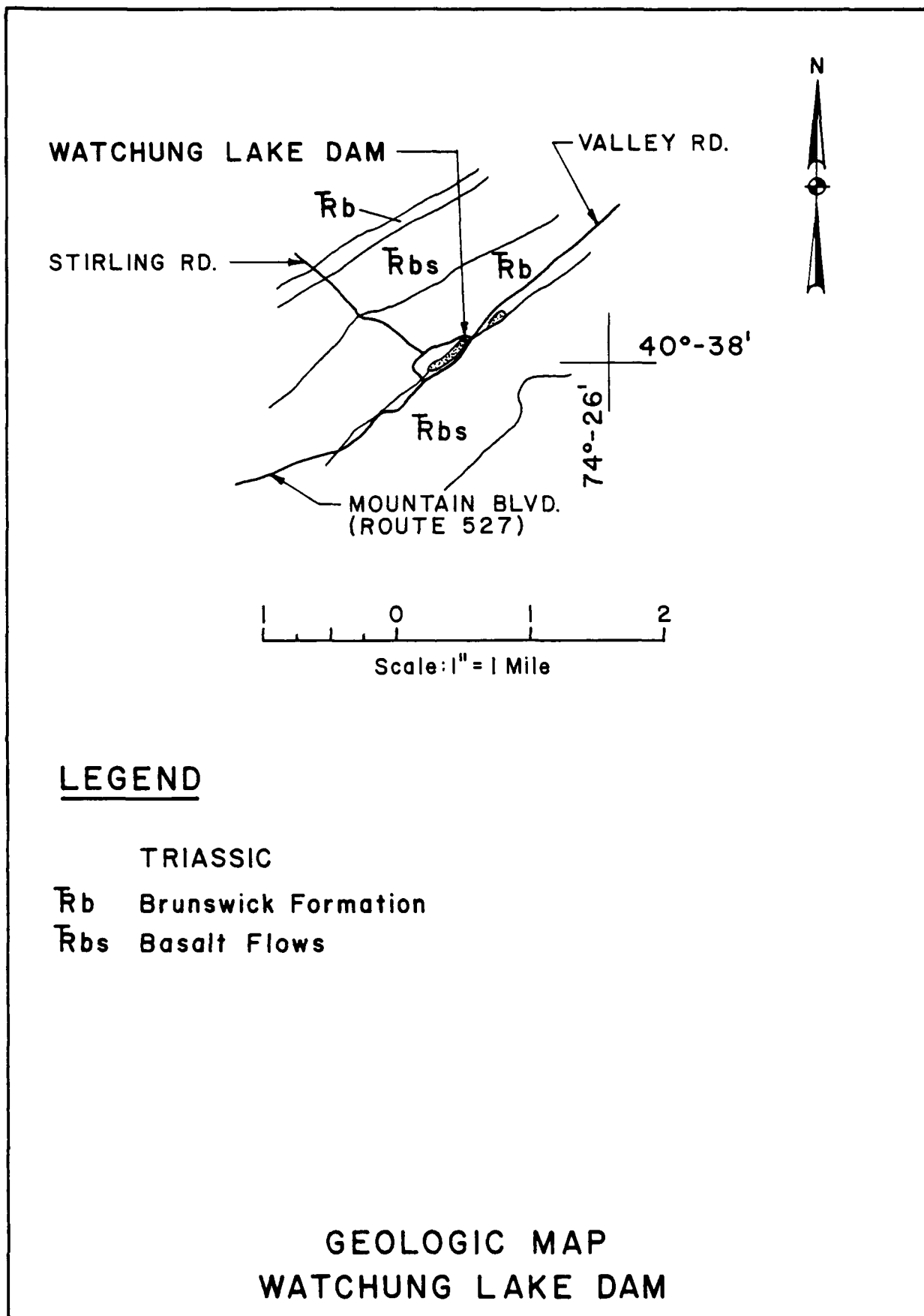
The owner should develop, within one (1) year after formal approval of the report, written operating procedures and a periodic maintenance plan to insure the safety of the dam.

P L A T E S

WATCHUNG LAKE DAM
BORO OF WATCHUNG
SOMERSET COUNTY, N. J.



KEY MAP



MOUNTAIN ROAD

SHORE LINE

195'

TOP OF EMBANKMENT

WOODEN

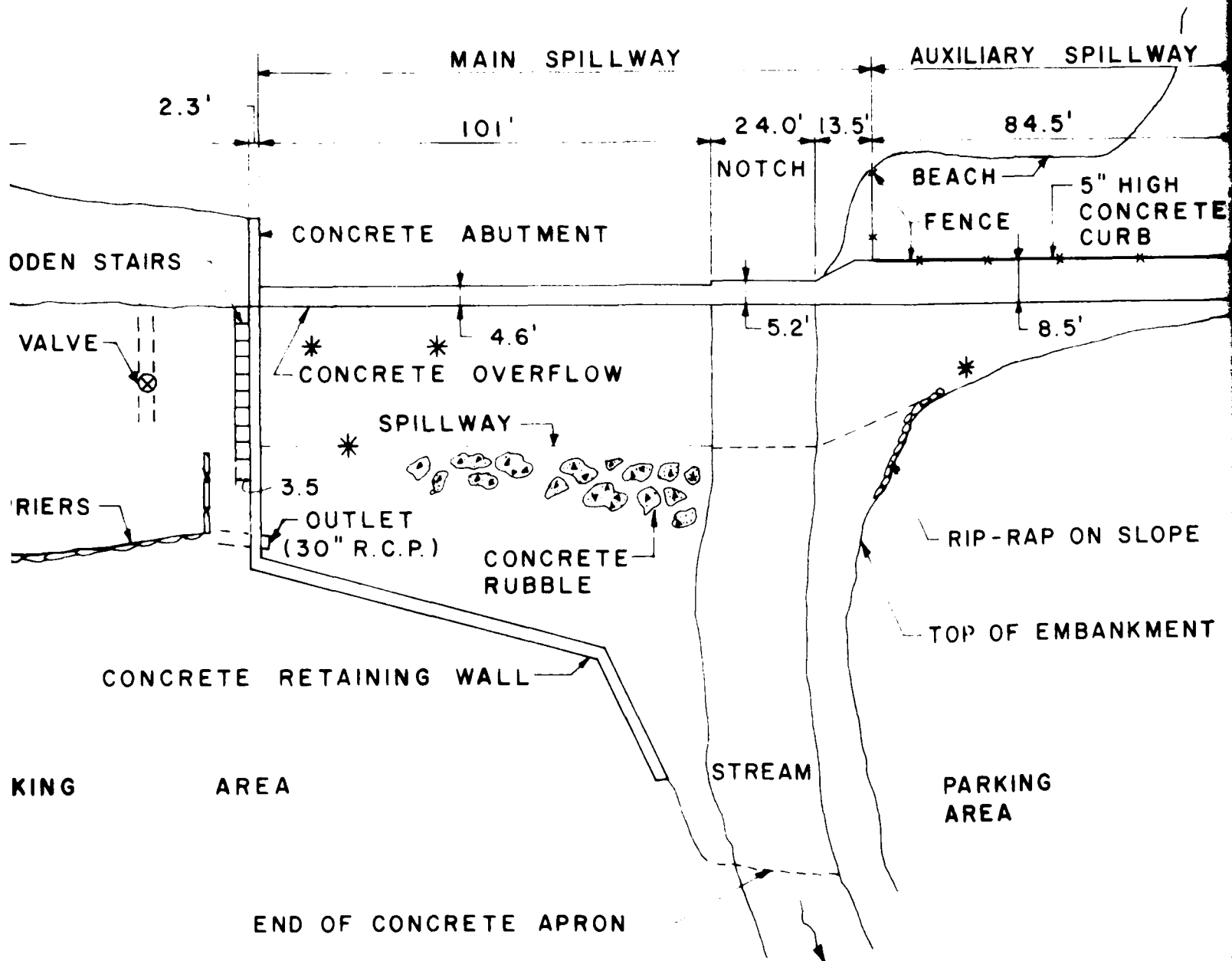
VALVE

OLD BROKEN
CONCRETE BARRIER

PARKING

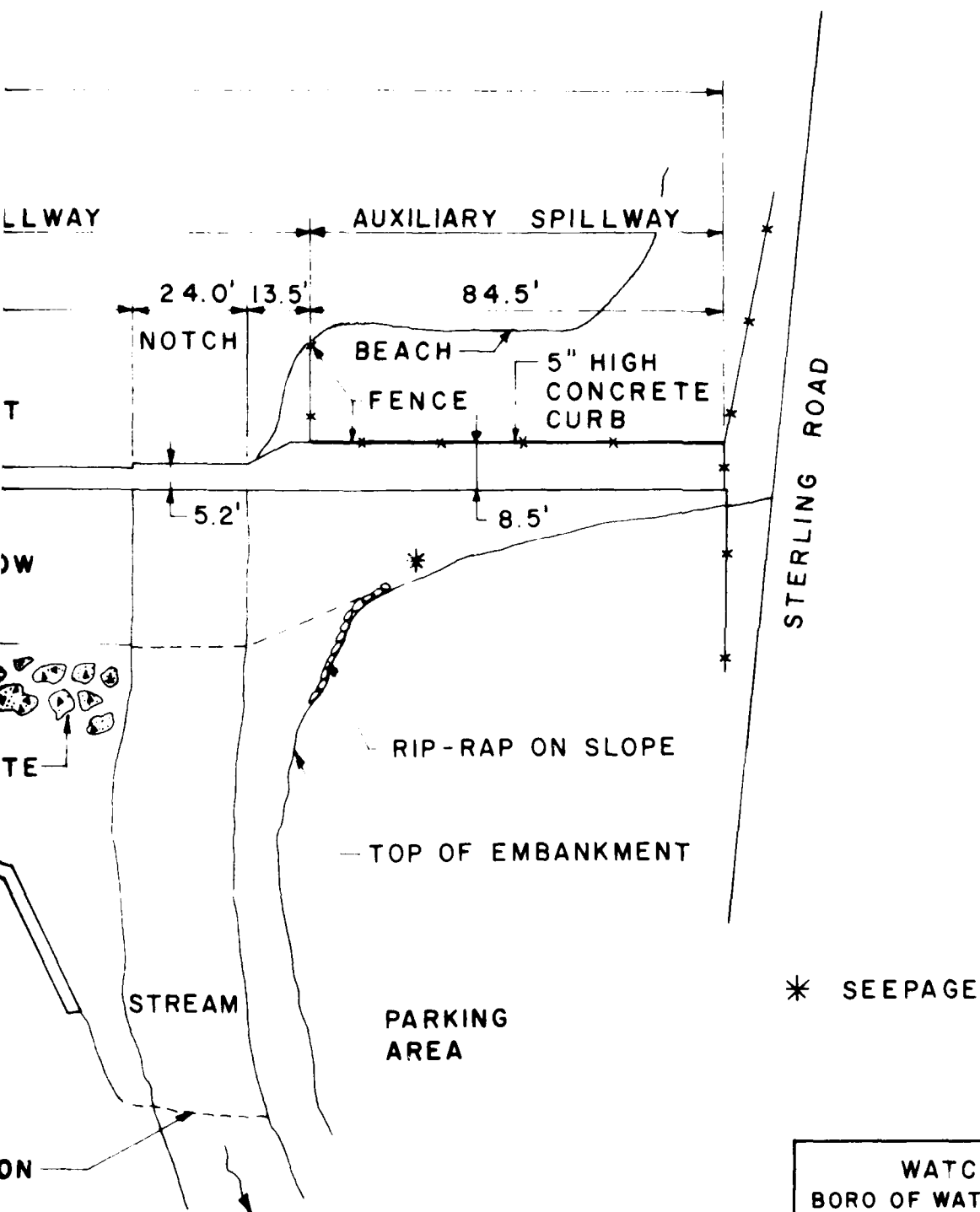
WATCHUNG LAKE

420'
(MEASURED DISTANCE)



PLAN

SCALE: 1" = 30'



WATCHUNG LAKE DAM
 BORO OF WATCHUNG, SOMERSET CO., N.J.

SKETCH OF PLAN
 PREPARED FROM FIELD NOTES TAKEN
 DURING INSPECTION ON JAN. 8, 1981

BY:
 HARRIS-ECI ASSOCIATES
 WOODBRIDGE, N.J.

SCALE: AS SHOWN
 DATE: FEB. 1981
 SHEET: 1 OF 1

APPENDIX A

CHECK LIST - VISUAL OBSERVATIONS

CHECK LIST - ENGINEERING, CONSTRUCTION
MAINTENANCE DATA

CHECK LIST
VISUAL INSPECTION

PHASE 1

Name Dam Watchung Lake Dam County Somerset State New Jersey Coordinators NJ-DEP

Date(s) Inspection January 8, 1981
February 25, 1981

Weather Partly Cloudy Temperature 20°F
Cloudy 45°F

Pool Elevation at Time of Inspection 202.2 NGVD Tailwater at Time of Inspection 184.5 NGVD

Inspection Personnel:

January 8, 1981

February 25, 1981

William Birch
Thomas Moroney
Joseph Sirianni (Recorder)

Joseph Sirianni

OWNER/REPRESENTATIVE:

January 8, 1981

John H. McDonough
307 Long Hill Drive
Short Hills, NJ 07078

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
SURFACE CRACKS None observed.		
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE None observed. The downstream slope has been reinforced by the placement of a double layer of old concrete barrier curbs along the toe.		
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES None noticed.		
VERTICAL & HORIZONTAL ALIGNMENT OF THE CREST The horizontal alignment of both the upstream and downstream edges of the crest are very irregular. The width varies from 20 feet to 71 feet. The vertical alignment appears good.		
RIPRAP FAILURES N/A		

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
EARTH EMBANKMENT	There are some trees and brush growing on the upstream slope. Numerous trees and brush growing along the crest at the downstream slope and on the slope. A few trees have been uprooted leaving cavities on the downstream slope.	Remove trees and brush. Fill in cavities with suitable material.
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Good.	
ANY NOTICEABLE SEEPAGE	See Ungated Spillway sheet for information on seepage.	
STAFF GAGE AND RECORDER	None.	
DRAINS	None.	

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
CRACKING & SPALLING OF CONCRETE SURFACES IN STILLING BASIN	Heavy spalling in the discharge channel and at the face of the concrete retaining wall running perpendicular to the dam and parallel to the discharge channel for the outlet pipe.	Repair spalled concrete.
INTAKE STRUCTURE	Low-level outlet drain underwater in lake. Not visible.	
OUTLET STRUCTURE	30-inch reinforced concrete pipe discharging parallel to the spillway. Flow is controlled by a wheel operated gate valve located in the downstream slope. The valve appears to be leaking slightly as there was water running in the pipe. At the time of inspection the wheel was missing hence the operation of the valve was not demonstrated.	Determine if valve is operable, and if not, make repairs as necessary.
OUTLET FACILITIES	None.	
EMERGENCY GATE	None.	

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
<p>CONCRETE WEIR</p> <p>Concrete blocks used to provide access across the notched weir to beach area are cracked & deteriorated. Concrete facing on top and downstream face of spillway is cracked and spalled. Seepage was observed on the downstream face 10 ft. and 35 ft. left of the right abutment approximately 1/3 of the way down from the crest, also 20 ft. left of abutment at the toe and 35 ft. left of the notch near the toe.</p>		<p>Repair all cracked and spalled concrete. Monitor the seepage to determine its volume.</p>
<p>APPROACH CHANNEL</p> <p>Watchung Lake is the approach channel for the dam.</p>		
<p>DISCHARGE CHANNEL</p> <p>Flow from the notched weir discharges onto a rough concrete channel that is in good condition. Flow from the remaining main spillway discharges onto the low-level outlet channel, and flow from the left auxiliary spillway discharges onto a concrete swale.</p>		
<p>BRIDGE AND PIERS</p> <p>None.</p>		

INSTRUMENTATION

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
MONUMENTATION/SURVEYS None.		
OBSERVATION WELLS None.		
WEIRS None.		
PIEZOMETERS None.		
OTHER None.		

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
SLOPES	The slopes are moderately flat with homes along the shoreline. A swimming area is on the left shore immediately upstream of the dam.	
SEDIMENTATION	None visible.	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS AND RECOMMENDATIONS
<p>CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)</p> <p>The channel is well defined and in good condition. There are some uprooted trees along the left bank.</p>		<p>Remove trees.</p>
<p>SLOPES</p> <p>The slopes are almost vertical and high (5'-6'). The banks are severely eroded causing the uprooting of some trees on left. Some concrete rubble has been placed on right bank just downstream of the end of the discharge apron.</p>		<p>Fill in the eroded areas with suitable material and place slope protection on the banks to prevent future erosion.</p>
<p>APPROXIMATE NUMBER OF HOMES AND POPULATION</p> <p>The channel crosses under Valley Road 350 feet downstream through a 6.5 ft. x 26 ft. opening and then under Watchung Avenue 1,000 feet downstream of spillway. A parking area for those using the lake is immediately downstream of the embankment. There are ten residential and commercial buildings located immediately downstream of the dam along the channel.</p>		

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM	REMARKS
PLAN OF DAM	None available.
REGIONAL VICINITY MAP	Available-Somerset County Map and U.S.G.S. Quadrangle Sheet for Chatham, NJ
CONSTRUCTION HISTORY	No formal history exists, but can be deduced from data available at NJ Department of Environmental Protection (NJ-DEP), 1474 Prospect Street, P.O. Box CN-029, Trenton, NJ 08625
TYPICAL SECTIONS OF DAM	None available.
HYDROLOGIC/HYDRAULIC DATA	None available.
OUTLETS - PLAN	None available.
- DETAILS	None available.
- CONSTRAINTS	None.
- DISCHARGE RATINGS	None available.
RAINFALL / RESERVOIR RECORDS	Not kept.

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
(continued)

ITEM	REMARKS
DESIGN REPORTS	None available.
GEOLOGY REPORTS	Available NJ-DEP, Geologic Overlay Sheet No. 25 and Engineering Soils Survey of New Jersey, Report No. 7, Somerset County, by Rutgers University (New Brunswick, NJ)
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None available.
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	None available.
POST-CONSTRUCTION SURVEYS OF DAM	None.
BORROW SOURCES	Unknown.
SPILLWAY PLAN - SECTIONS - DETAILS	None available.

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
(continued)

ITEM	REMARKS
OPERATING EQUIPMENT PLANS AND DETAILS	None available.
MONITORING SYSTEMS	None.
MODIFICATIONS	Existing spillway raised 4 to 6-inches, (year unknown) Concrete barrier curb placed along downstream toe of embankment and in the discharge channel in 1974.
HIGH POOL RECORDS	Not kept.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	None available.
PRIOR ACCIDENTS OF FAILURE OF DAM - DESCRIPTION - REPORTS	According to data available at the NJ-D.E.P., the dam was overtopped in 1945 and 1973. No information is available as to any damages to the dam or downstream of the dam.
MAINTENANCE OPERATION RECORDS	None known to exist.

APPENDIX B

PHOTOGRAPHS

WATCHUNG LAKE DAM



Photo 1 - View of spillways looking towards left end of dam from the embankment.

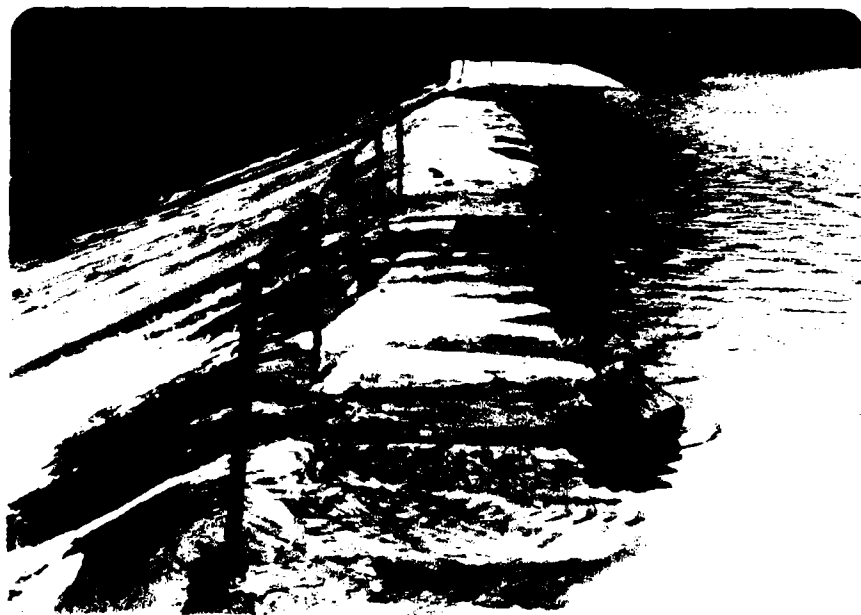


Photo 2 - View of main spillway with concrete blocks and railing to aid people crossing the dam to go to the swimming area. Note heavy growth of trees on downstream slope of embankment.

WATCHUNG LAKE DAM



Photo 3 - View of crest and upstream slope of embankment looking towards right end of dam.



Photo 4 - View of discharge swale for left auxiliary spillway looking towards left end of dam.

WATCHUNG LAKE DAM



Photo 5 - View of downstream slope of right auxiliary spillway looking upstream. Two wet areas down from the crest are seepage.

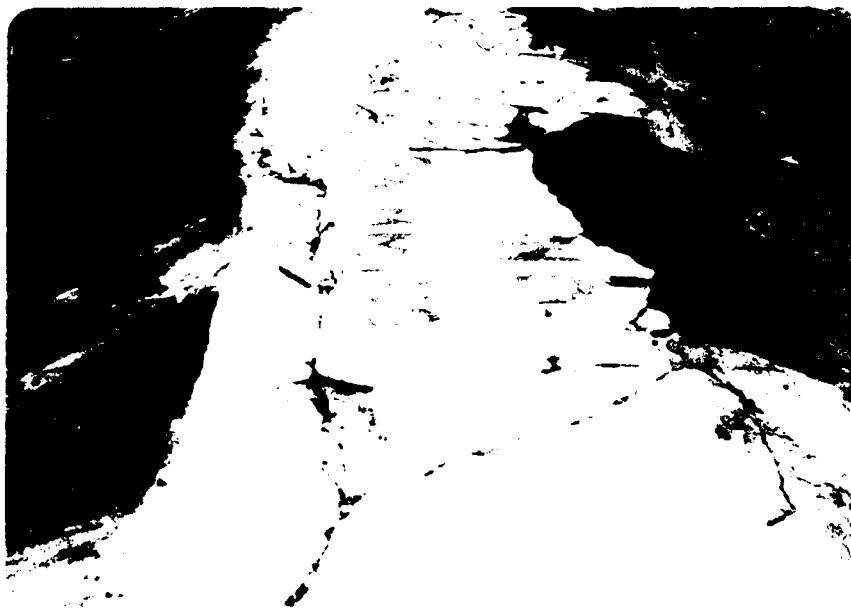


Photo 6 - View of cracked and deteriorated concrete capping on crest of right auxiliary spillway.

WATCHUNG LAKE DAM



Photo 7 - View of 30-inch R.C.P., low-level outlet, and concrete barrier curbs used for slope reinforcing.



Photo 8 - View of low-level outlet discharge channel looking towards left end of dam.

WATCHUNG LAKE DAM



Photo 9 - View of lake from spillway.



Photo 10 - View of main spillway looking upstream.

WATCHUNG LAKE DAM



Photo 11 - View of downstream channel from spillway.



Photo 12 - View of downstream channel showing erosion along left bank.

APPENDIX C

SUMMARY OF ENGINEERING DATA

1.

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

Name of Dam: WATCHUNG LAKE DAM

Drainage Area Characteristics: 3.49 square miles

Elevation Top Normal Pool (Storage Capacity): 200.15 NGVD (93 acre-feet)

Elevation Top Flood Control Pool (Storage Capacity): N/A

Elevation Maximum Design Pool: 204.36 NGVD (SDF pool: 175 acre-feet)

Elevation Top Dam: 203.2 ft. NGVD (149 acre-feet)

SPILLWAY CREST: Main: 200.15
a. Elevation Auxiliary: 201.3

b. Type Broadcrest

c. Width Main: 4.6 ft.
 Auxiliary: 8.5 ft.

d. Length Main: 138.5 ft.
 Auxiliary: 84.5 ft.

e. Location Spillover Entire length main spillway

f. No. and Type of Gates None

OUTLET WORKS:

a. Type 30 R.C.P.

b. Location In embankment - 25 ft. right of spillway.

c. Entrance Inverts Unknown

d. Exit Inverts 184.3 NGVD

e. Emergency Draindown Facilities 30 inch valve - 30 inch R.C.P.

HYDROMETEOROLOGICAL GAGES:

a. Type None

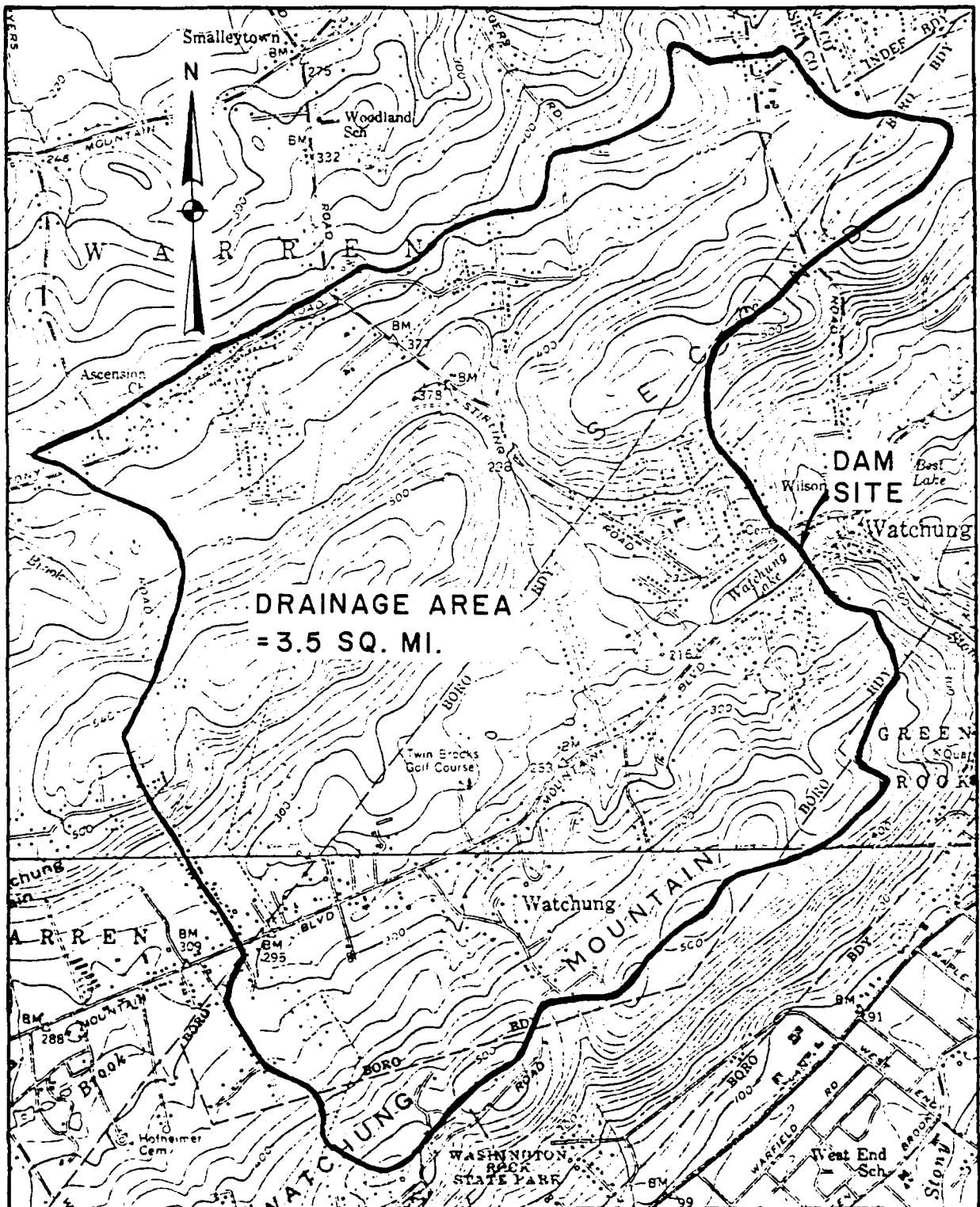
b. Location None

c. Records None

MAXIMUM NON-DAMAGING DISCHARGE: 3,133 cfs at elevation 203.2 NGVD

APPENDIX D

HYDROLOGIC COMPUTATIONS



2,000 0 2,000 4,000

Scale: 1" = 2,000 FT.

WATCHUNG LAKE DAM
DRAINAGE BASIN

Area of the Lake at normal pool level = 16 Ac.
Height of the Dam = 19.2 ft (max)
Small Dam, High Hazard
S.D.F = $\frac{1}{2}$ PMF

Hydrologic Analysis

D.A = 3.49 sq miles

Inflow hydrograph at reservoir was determined using HEC 1 DB program. Inflow routed through reservoir.

Reservoir stage area relationship

Elevation Area in Acres

183	0
200	16
220	56.5

Reservoir storage stage relationship was determined by HEC 10 DB Program from the area stage relationship.

Determination of PMP

Probable Maximum ppt. (inches) for an area of
10 square miles and 6 hour duration
= 26"

D.A. = 3.49 sq miles

ZONE = 6

The corps of Engineers recommended that
20 % reduction to be applied to the
report value for a 10 sq miles drainage
area in order to provide for the imperfect
fit of the storm isohyetal patterns to the
shape of the particular basin.

Because of the unlikelihood of a perfect
strike of a storm center on any particular
small basin, no variation is assumed between
point and 10 square miles precipitation

$$P.M.P. = 26" \times (1 - 0.2) = 20.8" \text{ (computer adopted)}$$

This adjustment in the program.

Depth area duration relationship.

Percentage to be applied to the above 6 hr PMP

$$6 \text{ hr} = 100 \%$$

$$12 \text{ hr} = 108 \%$$

$$24 \text{ hr} = 117 \%$$

$$48 \text{ hr} = 127 \% \text{ (Not necessary)}$$

Initial infiltration = 1"

Constant infiltration = 0.1"/hr.

Determination of T_c

- 1) Estimating T_c from velocity estimate and watercourse length

	Slope	Vel	Remarks
Overland flow	$\frac{520-400}{2,300} = 5.2\%$	3 FPS	Postures (upper portion of watershed)
Reach 1	$\frac{400-320}{5,000} = 2.4\%$	1 FPS	Upper portion of channel
Reach 2	$\frac{320-200}{6000} = 2\%$	1 FPS	Lower portion of channel

$$T_c = \frac{2300}{3 \times 3600} + \frac{5000 + 6000}{1 \times 3600} = 3.3 \text{ hrs.}$$

- 2) Estimating T_c assuming same velocity

$$\frac{13,300}{1.5 \times 3600} = 2.5 \text{ hrs}$$

- 3) From Nomograph of Design of Small Dam (SCS Guide) - Same as Kirpich

$$T_c = \left(\frac{11.9 L^3}{H} \right)^{.385} \quad \begin{array}{l} L \text{ in Miles} = 2.52 \\ H \text{ in Ft} = 320 \end{array}$$

$$= \left[\frac{11.9 \times (2.52)^3}{320} \right]^{.385}$$

$$= .82 \text{ hrs.}$$

Use $T_c = 2.0 \text{ hrs}$

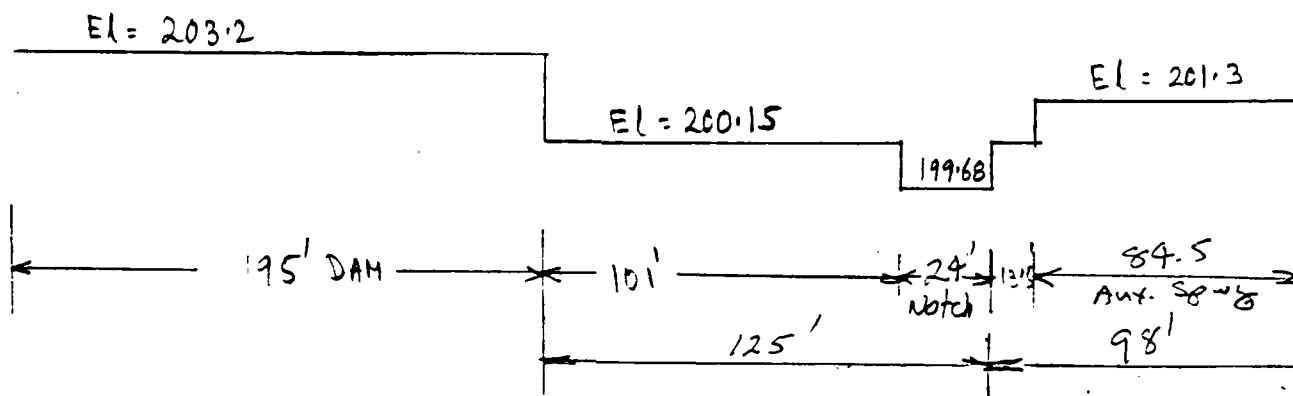
$$\text{Lag} = 0.6 \times 2 = 1.2 \text{ hrs.}$$

PRC Harris, Inc.
CONSULTING ENGINEERS

SUBJECT N.J. Dam Inspection
Watchung Lake Dam
COMPUTED BY S.B. CHECKED BY _____

SHEET NO. 4 OF _____
JOB NO. 10-1176-01
DATE March 1981

SCHEMATIC LAYOUT OF DAM



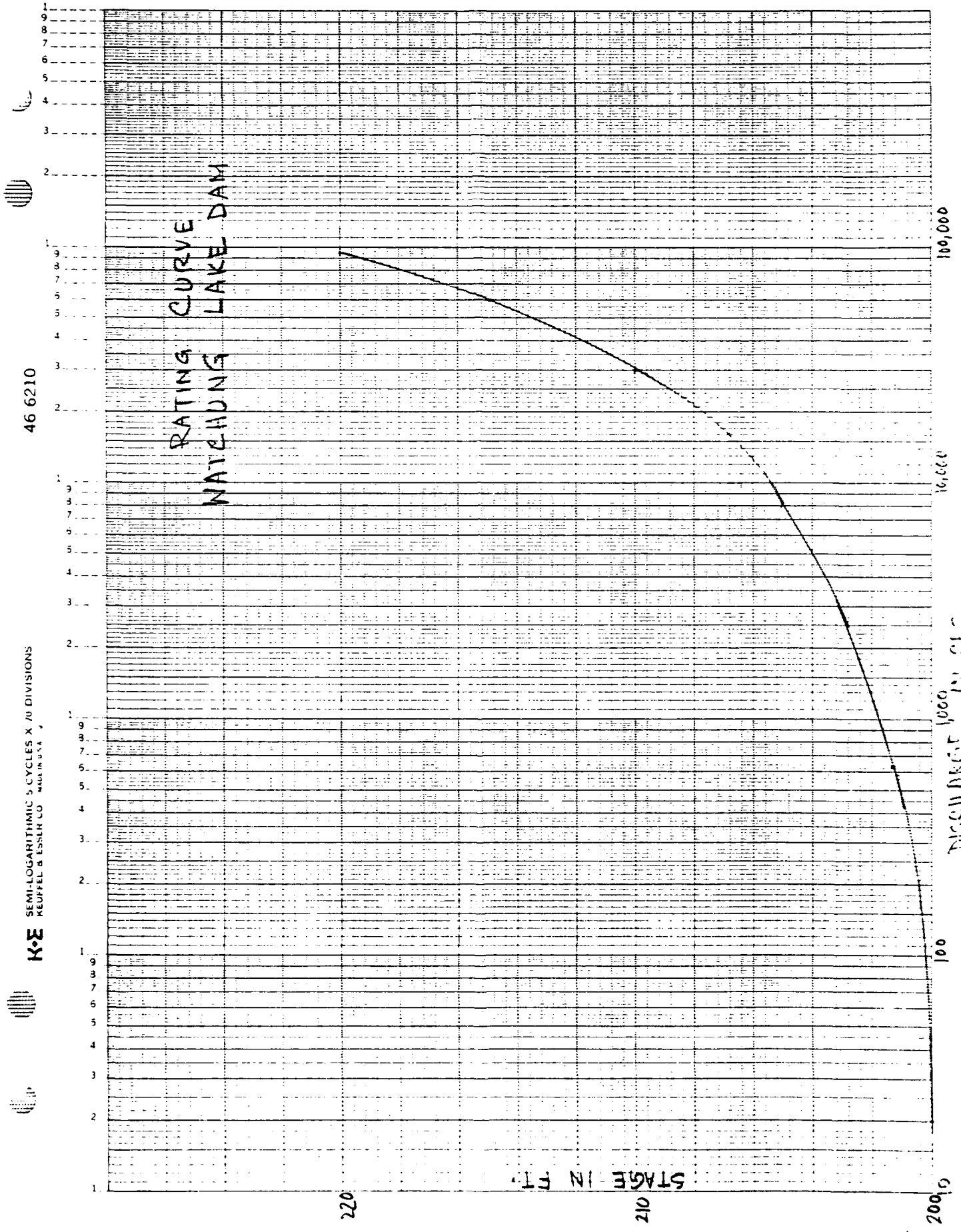
Notch. $L = 24' \quad C = 3.3 \quad Q = 3.3 \times 24 H^{3/2} = 79.2 H^{3/2}$

Main Spillway $L = 101 + 13.5 = 114.5 \quad C = 3.3$
 $Q = 3.3 \times 114.5 H^{3/2} = 378 H^{3/2}$

Aux. Spwy (Right looking U.S.) $L = 98 - 13.5 = 84.5 \quad C = 2.7$
 $Q = 2.7 \times 84.5 H^{3/2} = 228 H^{3/2}$

DAM (Left looking U.S.) $L = 195 \quad C = 2.7$
 $Q = 2.7 \times 195 H^{3/2} = 526 H^{3/2}$

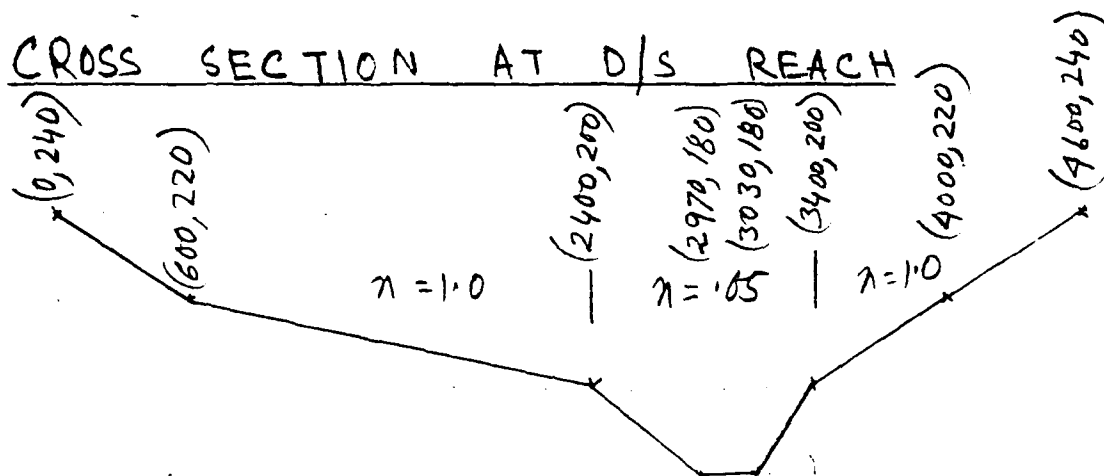
W.S. EL	Notch		MAIN SPILL		Aux. Spwy		DAM Left		Total
①	H	$Q = 79.2 H^{3/2}$	H	$Q = 378 H^{3/2}$	H	$Q = 228 H^{3/2}$	H	$Q = 526 H^{3/2}$	$3 + 5 + 7 + 9$
②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	
199.68	0	0	-	-	-	-	-	-	0
200.15	.47	26	0	0	-	-	-	-	26
201.3	1.62	163	1.15	466	0	0	-	-	629
203.2	3.52	523	3.05	2013	1.9	597	0	0	3133
205	5.32	972	4.85	4037	3.7	1623	1.8	1270	7902
210	10.32	2625	9.85	11685	8.7	5851	6.8	9327	29,488
215	15.32	4749	14.85	21631	13.7	11562	11.8	21,321	59,263
220	20.32	7255	19.85	33430	18.7	18437	16.8	36,220	95,342



PRC Harris, Inc.
CONSULTING ENGINEERS

SUBJECT N.J. Dam Inspection
Watchung Lake Dam
COMPUTED BY S.B. CHECKED BY _____

SHEET NO. 6 OF _____
JOB NO. 10-1176-01
DATE March 1981



Hazard Elevation = 180.0 (Estimated)

Reach 1

$$L = 1000 \text{ Ft}$$

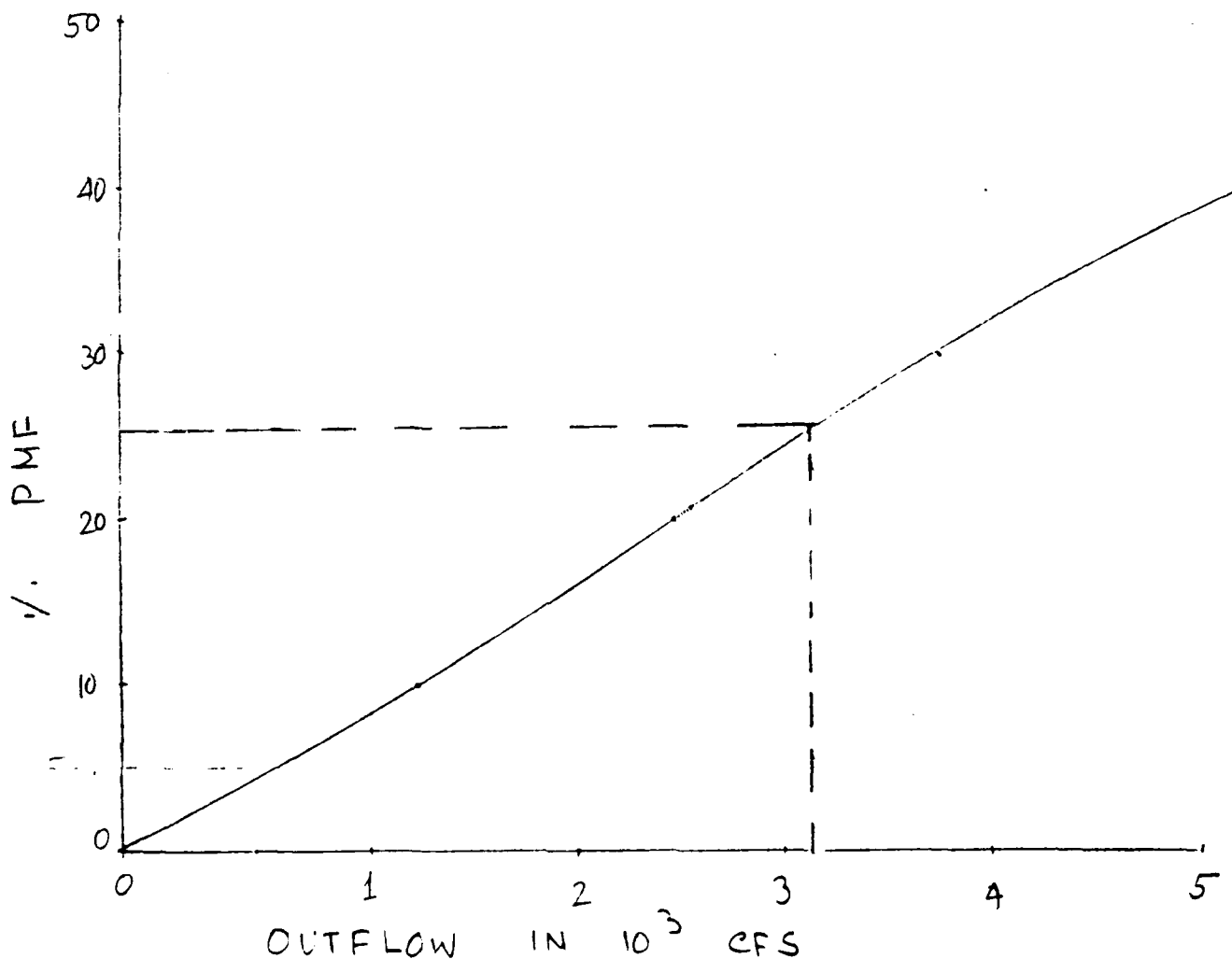
$$S = \frac{20}{1600} = .0125$$

section at crossing
near Mountain Blvd.

PRC Harris, Inc.
CONSULTING ENGINEERS

SUBJECT N. J. Dam Inspection
Watchung Lake Dam
COMPUTED BY S.B. CHECKED BY _____

SHEET NO. 7 OF _____
JOB NO. 10-1176-01
DATE March, 1981



Overtopping of Dam occurs at El 203.2
 $Q = 3133$ cfs (24% of PMF)

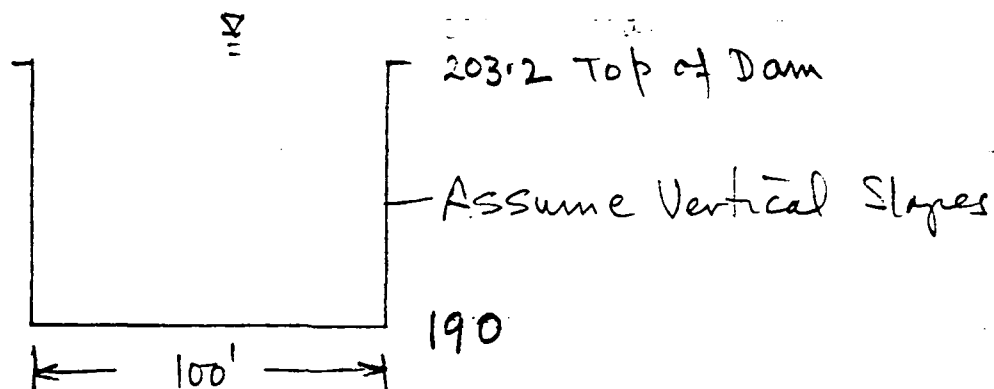
PRC Harris, Inc.
CONSULTING ENGINEER

SUBJECT N.J. Dam Inspection
Watchung Lake Dam
COMPUTED BY S.B.O. CHECKED BY _____

SHEET NO. 8 OF _____
JOB NO. 10-1176-01
DATE March, 1981

Breach Analysis

Assume breach begins to develop when
reservoir stage reaches above the Dam.
Time of failure = 16.50 hours



Effect of breach was analysed, 1,000 ft
Downstream of the Dam.

Max. stage without Dam break = 183.7

Max. stage with Dam break = 184.3

There will 0.6 ft increase in stage due
to dam break. at 0.3 PMF

Drawdown Computations

30" RCP
Inv = 184.33

There is a 30" RCP low level outlet at the center of the dam. Invert of the low level outlet is 184.33

Normal elevation to start = 200.15

Inflow = 2 cfs / mi² = 2. x 3.49 ≈ 7 cfs.

$$Q = CA \sqrt{2gh} \quad C = 0.62$$

$$= 0.62 \times \left[\frac{\pi}{4} \times (2.5)^2 \right] \times \sqrt{2g} \times \sqrt{h}$$

$$= 24.4 \sqrt{h}$$

Assume tailwater elevation = 185.0 NGVD

$$\text{Area } A_2 = \left(\frac{h_2}{h_1} \right)^2 A_1 = \left(\frac{h_2}{17.15} \right)^2 \times 16 = 0.544 h_2^2$$

$$\text{Drawdown time } t = \frac{\text{Vol in AF} \times 43560}{Q \times 3600} = \frac{12.1 \times 1600}{Q} \text{ Hrs}$$

$$\text{Drawdown time with inflow} = \frac{7 \times t}{Q} \text{ Hrs}$$

SUBJECT N.J. Dam Inspection
Watchung Lake Dam
COMPUTED BY S.S.B. CHECKED BY _____

SHEET NO. 10 OF
JOB NO. 10-1176-01
DATE March 1961

RES EL.	Area	Av. Area	VOL	h	CFS	Drawdown $t = 12.1 \times \frac{VOL}{Q}$	Cum Time	Drawdown with inflow $7\frac{1}{2}Q$ (HRS)	Cum Time
FT	AC	AC	AF	FT	CFS	HRS	HRS	HRS	HRS
200.15	16								
198	12.24	14.12	30.36	14.075	91.54	4.01	4.01	.31	4.32
196	9.19	10.72	21.44	12	84.52	3.07	7.08	.25	7.64
194	6.58	7.88	15.76	10	77.16	2.47	9.55	.22	10.33
192	4.41	5.49	10.98	8	69.01	1.93	11.48	.20	12.46
190	2.67	3.54	7.08	6	59.77	1.43	12.91	.17	14.06
188	1.36	2.01	4.02	4	48.80	1.00	13.91	.14	15.20
186	0.49	0.93	1.86	2	34.51	.65	14.56	.13	15.98
185	0.22	0.36	0.36	0.5	17.25	.25	14.81	.10	16.33

0.22 → Tailwater

193 0 El al Reservoir Area = 0

Time of Drawdown without inflow = 14.81 hrs

Time of Drawdown with inflow = 16.33 hrs.

[illegible]

ALSO: THE PROPERTY
WATCHDOG TAKE CARE
MULTI-COLORED ROUTING

JO. SPECIFICATION									
NO.	REV.	DATE	BY	CHKD.	WTRC	PLT	POST	NSIAN	5
1	1	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
2	2	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
3	3	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
4	4	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
5	5	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
6	6	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
7	7	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
8	8	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
9	9	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
10	10	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
11	11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
12	12	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
13	13	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
14	14	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
15	15	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
16	16	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
17	17	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
18	18	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
19	19	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
20	20	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
21	21	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
22	22	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
23	23	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
24	24	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
25	25	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
26	26	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
27	27	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
28	28	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
29	29	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11	11/11/11
30	30	11/11/11	11/11/11	11/11/11	11/11/11	11/			

ANALYSIS TO BE PERFORMED

01°0	02°0	05°0	06°0	07°0
01°0	02°0	05°0	06°0	07°0

SUN-ARCA/RUNOFF COMPUTATION.

[illegible]

HYDROGRAPH DATA									
DATE	TIME	TEMP	WIND	WAVE	IRSPC	IRSNOW	RATIO	ISANE	LOCAL
10-05	14-00	0.1	0.1	0.1	0.00	0.00	0.00	0	0

REF ID: A7A

DATE	DESCRIPTION	AMOUNT	BALANCE
1966	1/1	100.00	100.00
1966	2/1	100.00	200.00
1966	3/1	100.00	300.00
1966	4/1	100.00	400.00
1966	5/1	100.00	500.00
1966	6/1	100.00	600.00
1966	7/1	100.00	700.00
1966	8/1	100.00	800.00
1966	9/1	100.00	900.00
1966	10/1	100.00	1000.00
1966	11/1	100.00	1100.00
1966	12/1	100.00	1200.00
1967	1/1	100.00	1300.00
1967	2/1	100.00	1400.00
1967	3/1	100.00	1500.00
1967	4/1	100.00	1600.00
1967	5/1	100.00	1700.00
1967	6/1	100.00	1800.00
1967	7/1	100.00	1900.00
1967	8/1	100.00	2000.00
1967	9/1	100.00	2100.00
1967	10/1	100.00	2200.00
1967	11/1	100.00	2300.00
1967	12/1	100.00	2400.00
1968	1/1	100.00	2500.00
1968	2/1	100.00	2600.00
1968	3/1	100.00	2700.00
1968	4/1	100.00	2800.00
1968	5/1	100.00	2900.00
1968	6/1	100.00	3000.00
1968	7/1	100.00	3100.00
1968	8/1	100.00	3200.00
1968	9/1	100.00	3300.00
1968	10/1	100.00	3400.00
1968	11/1	100.00	3500.00
1968	12/1	100.00	3600.00
1969	1/1	100.00	3700.00
1969	2/1	100.00	3800.00
1969	3/1	100.00	3900.00
1969	4/1	100.00	4000.00
1969	5/1	100.00	4100.00
1969	6/1	100.00	4200.00
1969	7/1	100.00	4300.00
1969	8/1	100.00	4400.00
1969	9/1	100.00	4500.00
1969	10/1	100.00	4600.00
1969	11/1	100.00	4700.00
1969	12/1	100.00	4800.00
1970	1/1	100.00	4900.00
1970	2/1	100.00	5000.00
1970	3/1	100.00	5100.00
1970	4/1	100.00	5200.00
1970	5/1	100.00	5300.00
1970	6/1	100.00	5400.00
1970	7/1	100.00	5500.00
1970	8/1	100.00	5600.00
1970	9/1	100.00	5700.00
1970	10/1	100.00	5800.00
1970	11/1	100.00	5900.00
1970	12/1	100.00	6000.00
1971	1/1	100.00	6100.00
1971	2/1	100.00	6200.00
1971	3/1	100.00	6300.00
1971	4/1	100.00	6400.00
1971	5/1	100.00	6500.00
1971	6/1	100.00	6600.00
1971	7/1	100.00	6700.00
1971	8/1	100.00	6800.00
1971	9/1	100.00	6900.00
1971	10/1	100.00	7000.00
1971	11/1	100.00	7100.00
1971	12/1	100.00	7200.00
1972	1/1	100.00	7300.00
1972	2/1	100.00	7400.00
1972	3/1	100.00	7500.00
1972	4/1	100.00	7600.00
1972	5/1	100.00	7700.00
1972	6/1	100.00	7800.00
1972	7/1	100.00	7900.00

JOSEPH J. JAIN, JR. AND THE BOARD OF DIRECTORS

OS: DATA

[illegible]

1947

PROPOSITION DATA

00-2 200111 50000 20000 20000

UNIT	NO. OF	24 HRS. OF	LEAD	ORIGINATING	TS	0400 HOURS	LAGS	1-23	VOLS	1-00
1117	3	7	110	157	1236	1073	451	27	20	430
151	33	176	124	3	68	50	27	20	430	430

UNCLASSIFIED//FOR OFFICIAL USE ONLY

[illegible]

W.D. JAM INSPECTION
MATCHING LAMP CAP
W.D. JAM ANALYSIS

4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000 1001 1002 1003 1004 1005 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 1040 1041 1042

[illegible]

